

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
15 September 2005 (15.09.2005)

PCT

(10) International Publication Number
WO 2005/085132 A2

(51) International Patent Classification⁷: **C01B 31/00**

(21) International Application Number:
PCT/US2004/034002

(22) International Filing Date: 14 October 2004 (14.10.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/511,175 14 October 2003 (14.10.2003) US
60/587,234 12 July 2004 (12.07.2004) US
60/598,630 4 August 2004 (04.08.2004) US

(71) Applicant (for all designated States except US):
WILLIAM MARSH RICE UNIVERSITY [US/US];
6100 Main, Houston, TX 77005 (US).

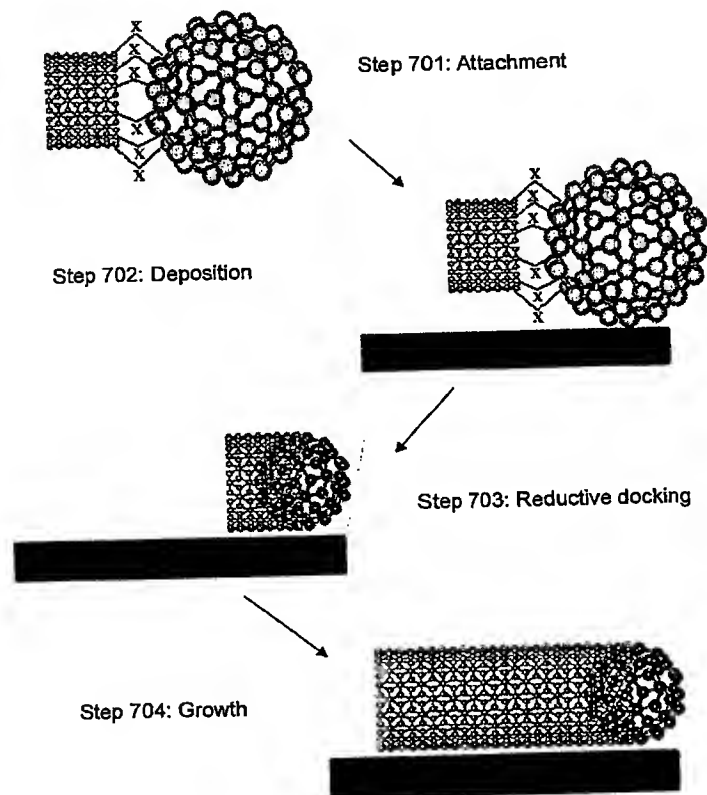
(72) Inventors; and

(75) Inventors/Applicants (for US only): **SMALLEY,**
Richard, E. [US/US]; 1816 Bolsover St., Houston,

TX 77005 (US). **HAUGE, Robert, H. [US/US];** 4031 Turnberry Circle, Houston, TX 77005 (US). **BARRON, Andrew, R. [GB/GB];** 241 Asbury, Houston TX 77007 (GB). **TOUR, James, M. [US/US];** 4625 Spruce Street, Bellaire, TX 77401 (US). **SCHMIDT, Howard, K. [US/US];** 2402 Bellefontaine, Houston, TX 77030 (US). **BILLUPS, W., Edward [US/US];** 6416 Rutgers, Houston, TX 77005 (US). **DYKE, Christopher, A. [US/US];** 19611 Spoonwood Drive, Humble, TX 77346 (US). **MOORE, Valerie, C. [US/US];** 2255 Braeswood Park Drive, No. 139, Houston, TX 77030 (US). **WHITSITT, Elizabeth [US/US];** 806 LaMonte Lane, Houston, TX 77018 (US). **ANDERSON, Robin, A. [US/US];** 7490 Brompton Road, No. 172, Houston, TX 77025 (US). **COLORADO, Ramon, Jr. [US/US];** 5104 Irving Way, Houston, TX 77087-3629 (US). **STEWART, Michael [US/US];** 2829 Lockett Street, Houston, TX 77021 (US). **OGRIN, Douglas, C. [US/US];** 2825 Bellefontaine, No. 240A, Houston, TX 77025 (US).

[Continued on next page]

(54) Title: AMPLIFICATION OF CARBON NANOTUBES VIA SEEDED-GROWTH METHODS



(57) Abstract: The present invention is directed towards methods (processes) of providing large quantities of carbon nanotubes (CNTs) of defined diameter and chirality (i.e., precise populations). In such processes, CNT seeds of a pre-selected diameter and chirality are grown to many (e.g., hundreds) times their original length. This is optionally followed by cycling some of the newly grown material back as seed material for regrowth. Thus, the present invention provides for the large-scale production of precise populations of CNTs, the precise composition of such populations capable of being optimized for a particular application (e.g., hydrogen storage). The present invention is also directed to complexes of CNTs and transition metal catalyst precursors, such complexes typically being formed en route to forming CNT seeds.

WO 2005/085132 A2

BEST AVAILABLE COPY



(74) **Agents:** GARSSON, Ross Spencer et al.; WINSTEAD SECHREST & MINICK P.C., P.O. Box 50784, Dallas, TX 75201 (US).

(81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH,

GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declaration under Rule 4.17:

— *of inventorship (Rule 4.17(iv)) for US only*

Published:

— *without international search report and to be republished upon receipt of that report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.